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ABSTRACT

The purpose of this study was to examine teaching assistants' conceptions of the nature of teaching after they were taught a pedagogical strategy directly related to their subject matter. Four teaching assistants who taught the Biology 1201 laboratories at the University of Minnesota participated in this study which included participating in 16 hours of pre-quarter instruction and weekly 3-hour pre-laboratory instruction, and teaching a total of 10 laboratories. Their conceptions of the nature of teaching were examined using the Nature of Teaching Questionnaire and three interviews, before, during, and after the instruction and teaching the laboratories. Before the quarter, most of the teaching assistants had either subject matter knowledge and/or pedagogical knowledge conceptions of the nature of teaching. The comparison between pre- and post-experience conceptions revealed that their conceptions of the nature of teaching changed dramatically after participating in the instruction and teaching the laboratories toward a pedagogical subject matter knowledge conception. The post evaluation revealed that they showed a consistent relationship toward the use of pedagogical subject matter knowledge in the areas of assessment of student understanding and evaluation of instruction. Appendices include questionnaire and interview questions. Contains 24 references. (Author/JRH)

Learning To Teach: Teaching Assistants Conception Changes About Science Teaching

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Abstract

The purpose of this study was to examine teaching assistant's conceptions of the nature of teaching after they were taught a specific pedagogical strategy directly related to their subject matter. Four teaching assistants, who taught the Biology 1201 laboratories, participated in this study. The teaching assistants participated in sixteen hours of pre-quarter instruction, plus weekly three hour pre-laboratory instruction and taught a total of ten laboratories throughout the quarter. The teaching assistants' conceptions of the nature of teaching were examined using the Nature of Teaching Questionnaire and three interviews before, during, and after the instruction and teaching the laboratories. Before the quarter, most of the teaching assistants had either subject matter knowledge and/or pedagogical knowledge conceptions of the nature of teaching. The comparison between pre and post-experience conceptions revealed that teaching assistants' conceptions of the nature of teaching changed dramatically after participating in the instruction and teaching the laboratories toward a pedagogical subject matter knowledge conception. In comparing the two measures, on the post evaluation, it revealed that the teaching assistant's showed a consistent relationship toward the use of pedagogical subject matter knowledge in the areas of assessment of student understanding and evaluation of instruction.

INTRODUCTION

In the past twenty-five years, science education has experienced a paradigm shift from behaviorism to cognition. Educators are looking for an alternative to the traditional positivists view that teaching is the transmission of objective knowledge and that learning is the objective absorption of knowledge. As Shymansky and Kyle (1992) explain, a constructivist epistemology underlies much of the current reform initiative in education. Constructivism implies that learners are actively constructing their reality of the world. This paradigm shift has placed new expectations on our future science teachers in higher education. Teaching is no longer simply telling, it is understanding the learner and implementing teaching methods such as cooperative group learning; problem solving; conceptual change; and inquiry. With this paradigm shift a renewed interest in teaching practices in higher education is occurring, causing a need for graduate teaching assistants to "catch up" with the new conceptions of what is effective teaching.

The widespread use of teaching assistants as college teachers have created concern for their preparation. Not only are these concerns voiced by university administrators who are demanding classroom accountability (Carroll, 1980), but by those outside the university as well. The America 2000 program and the 1983 report A Nation at Risk has brought educational concerns to the forefront of public opinion (Anderson, 1992). As a result many academic departments are rethinking their approaches to teaching assistant preparation. Researchers have also responded to these situation factors by focusing more attention on teaching assistant instructional programs. Yet, as Carroll (1980) argues, although there is plenty of information concerning how to instruct teaching assistants, there is very little concerning how well these methods actually work.

Today, graduates are expected to be well versed in teaching methods as well as their subject matter knowledge to obtain employment in higher education. This necessity of preparing our future graduates to be effective teachers are both a marketing issue and an educational issue. As Staton and Darling (1989) observed in their study of teaching assistants, the very fact of being a teaching assistant influences the thoughts and feelings teaching assistants have about the institution, as well as their future choice of career emphasis and discipline concentration when they join the ranks

of the professorate. If graduates are to keep up with the expectations of the cognitive paradigm and obtain the ability to gain employment, then they must be instructed in pedagogical theory in direct combination with their subject matter knowledge. Research suggests that there is even more at stake. Teaching assistants play a significant role in helping to define and strengthen the overall quality of teaching in the university and, in effect, the university itself.

For a number of years graduates have been instructing classes in higher education. The instruction they receive on teaching methods varies. With the rise of the cognitive paradigm and the new interest in teaching practices at the higher education level, the instruction we are providing our teaching assistants in how to teach their classes needs to be evaluated. Along with evaluating the instruction, the conceptions teaching assistants hold about teaching must be examined. Shulman (1986) has criticized research on teaching for the assumption that the teaching of any one subject is like the teaching of any other subject. An examination of different disciplines reveals that the nature of knowledge in different domains is not the same. The concern is that there are fundamental differences between content domains, and with this concern comes the realization that subject matter dependent instructional strategies are required (Finley, in review). In addition research on teaching indicate that teaching is a complex cognitive skill, a skill that requires the construction of plans and the making of rapid on-line decisions (Leinhardt & Greeno, 1986). The implication of the cognitive paradigm of teaching in science has important ramifications in preparing our future teachers to teach students to understand scientific knowledge and not just a laundry list of terms. What is needed is science courses and educational methods courses that directly model the instructional practices that teachers will be expected to use in the classroom. The teaching assistants in this study confirmed prior research that supported the importance of instructional programs in preparing and influencing teaching assistants as they began their work (Andrews, 1985; Boehrer & Sarkisian, 1985; Boyer, 1990; Carroll, 1980; Smock & Menges, 1985).

The population of science teaching assistants at most universities are graduate students majoring in science disciplines. These teaching assistants instruct the majority of undergraduate science laboratories and discussions (Moore, 1991; Travers, 1989). Many of these teaching assistants have had little or no prior instruction or experience in teaching or pedagogical theory (Monaghan, 1989). They are left to rely on their own experiences as students and whatever minimal instruction they may have received. According to Wilson and Stearns (1985) it is quite common for the emphasis

of instructional sessions to be on the subject matter, while pedagogy is given little attention. These researchers maintained that teaching assistants would prefer more help with the "how to's" of teaching.

This study grew out of the idea that teachers need to know both science subject matter and pedagogy to teach science well (Vaidya, 1993). As Shulman (1986,1987) argues, it is not enough to have good generic teaching skills, rather, each discipline requires its own teaching strategies. Hence, teachers' subject matter knowledge as well as their pedagogical knowledge are both issues of concern. The thesis of this study is that if teaching assistants are taught pedagogical theory that is directly related to their subject matter, then their conceptions of teaching will change from conceptions of either subject matter knowledge or pedagogical knowledge toward the use of pedagogy directly combined with subject matter knowledge. This combined knowledge is referred to as pedagogical subject matter knowledge.

The exact definition of pedagogical subject matter knowledge has not been decided upon in the literature. Shulman (1986, 1987) says that pedagogical subject matter knowledge is using teaching strategies that are specific to the discipline. Alternatively, Berliner (1990) says that pedagogical subject matter knowledge is the integration of both pedagogical knowledge and subject matter knowledge into the ability to use both in a way that is instructionally appropriate. For example, teaching about Evolution requires subject matter knowledge about Biology, and it also requires a transformation of that knowledge into something a learner can understand. Through analogy and metaphor, and though multiple representations, through mechanisms that tie the topic to the students' own life experiences, subject matter knowledge may be transformed into pedagogical subject matter knowledge.

In this study, Berliner's definition was used. The reason Berliner's view was used was that it is more generic and it implies that the teacher understand that students may have misunderstandings and that the teachers are able to use both knowledge structures to correct their misunderstandings. This view also fits into the underlying principle of the teaching strategy employed in the instruction the teaching assistants received, that being conceptual change teaching.

Teaching assistant instruction does exist in most departments and at most Universities, however, it is usually little more than a review of course materials and procedures. If teaching assistants follow typical patterns, they will teach as they were taught and continue without the benefit of understanding current research and theories about teaching strategies that help students construct knowledge. If the instruction provided by teaching assistants is to improve, they will need to learn the basics of

pedagogical theory. More specifically, recent research on teaching indicates that they must learn pedagogical theory that is directly related to the subject matter they will teach (Berliner, 1989, Shulman, 1986,1987). This research also suggests that together with the broad information and assistance provided to teaching assistants through the university-wide program, teaching assistants need to have the kind of discipline-specific instruction that can only be provided at the departmental level.

This study was developed to investigate the conceptions of teaching employed by teaching assistant's in the General Biology 1201 course. The course was designed using the conceptual change teaching methodology. The teaching method came out of the cognitive paradigm that views the students as active participates in their own meaning making of knowledge. The conceptual change strategy is based on the pedagogical theory that acknowledges that students hold their own conceptions about scientific topics. The instructor's role is to challenge the students' conceptions to help students change their conceptions to the currently accepted scientific conception. The instruction for the laboratories was aimed at combining a specific pedagogical theory with the subject matter of biology. Because the graduate students needed to teach the laboratories in a manner very different from the manner in which they were taught, they were instructed on the conceptual change teaching strategy that was used to design the course. The instruction provided discussion and practice on the pedagogical theories of conceptual change teaching, method of problem solving strategies, approaches to using inquiry, and cooperative grouping techniques directly related to the subject area of biology. The instruction involved considerable effort, including a pre-quarter session of 16 hours, plus weekly three hour pre-laboratory sessions in which the graduate teaching assistants received supplementary instruction on the teaching theory and the subject matter to be taught.

The evaluation of this study requires an in-depth examination of the changes that occur in the teaching assistants' conceptions of teaching. This includes developing a rich description of changes in their thinking regarding characteristics and knowledge that are needed to be a good teacher, what is the best way to teach, what is important to teach, how to plan for a lesson, how to make decisions during instruction, and how to assess for student understanding. To document changes, this description must begin before the teaching assistant instruction and continue throughout the teaching assistants' initial teaching experience. The descriptions of the changes that occur cannot be fully anticipated and have not been previously described. The development of a rich description of changes in the teaching assistants thinking about their teaching will provide information needed to improve our theories of teaching

people how to teach. It should also provide information that is needed to develop better educational programs for teaching assistants.

The primary purpose of this study were as follows:

1. To describe the changes in teaching assistants' conceptions of the nature of teaching that are associated with the instruction and teaching the laboratories throughout the quarter, as indicated by the Nature of Teaching questionnaire?
2. To describe the changes in teaching assistants' conceptions of the nature of teaching that are associated with the instruction and teaching the laboratories throughout the quarter, as expressed in the interviews?
3. What relationships are there between teaching assistants' conceptions of the nature of teaching measured by the Nature of Teaching questionnaire and their expressions of those views in the interviews during the research experience toward the pedagogical subject matter knowledge conception?

Method

Subjects

The participants for the study were four teaching assistants who taught the laboratory sections for General Biology 1201 during the Fall quarter of 1993 at the University of Minnesota. There are approximately 40 teaching assistants currently employed by the General Biology Department. These four teaching assistants were selected based on their past teaching performance in Biology 1009.

The participants for this study consisted of two women and two men, all with various backgrounds of experience in teaching but all of which are graduate students in a field of science. The average age of the participants was 27 years. Below is a description of each teaching assistant.

Teaching Assistant #1 is a female master's student in conservation biology and holds two majors in biology and religion. This teaching assistant has taught college science laboratories for two years. Previous training includes the general biology introductory training program, one and a half year teaching English in Costa Rica at a cultural center and going to workshops occasionally. This teaching assistant has had no education classes. Future plans are unsure.

Teaching Assistant #2 is a male doctoral student in conservation biology. This teaching assistant has taught college science laboratories for one year. Previous

training includes one year. This teaching assistant has had some exposure to pedagogy. Future plans include college teaching.

Teaching Assistant #3 is a female doctoral student in conservation biology. This teaching assistant has taught college science laboratories for 5 quarters. Previous training includes a few workshops and a 2 credit course on college biology teaching. This teaching assistant has had little exposure to pedagogy. Future plans include college teaching.

Teaching Assistant #4 is a male doctoral student in history of science and technology. This teaching assistant has taught college science laboratories for one year. Previous training includes one workshop on leading small groups. This teaching assistant has had no exposure to pedagogy. Future plans include college teaching.

Design

The research was conducted as a study of four teaching assistants. The four cases were analyzed pre and post using two measures. The first three weeks of the quarter were the pretest and the last three weeks of the quarter were the post test. The remaining four weeks of the quarter, in the middle, served as the transition period. Before the research experience, all four teaching assistants who taught Biology 1201 were asked to complete a questionnaire to measure their conceptions of the nature of teaching. During the research experience, all teaching assistants were interviewed three times after three separate lessons responding to questions on their reflection of the lesson. After the research experience, all the teaching assistants completed the same questionnaire on the nature of teaching.

Instruments

The Nature of Teaching Questionnaire

The Nature of Teaching Questionnaire was comprised of 20 items selected from numerous research studies on teaching (Berliner 1987, 1988, 1989; Clark and Peterson, 1986; Livingston and Borko, 1989). The questions were selected based on whether they pertained to teaching in general, planning, assessment of understanding, or effectiveness of instruction. These four categories were used because together they look at the entire decision making process that goes into teaching. The questionnaire constituted the instrument for assessing teaching assistants' perceptions of the nature of teaching. The goal was to determine if teaching assistants' conceptions of the nature

of teaching change, after having instruction on pedagogy that is subject matter specific and after having taught this way throughout the course, toward the use of pedagogical subject matter knowledge as revealed on the questionnaire, interviews and field notes.

The questionnaire was broken down into four categories of teaching: teaching in general, planning, assessment, and effectiveness of instruction (Appendix A). The intent of the categories was to get at the entire process of decision making involved in teaching a laboratory. The questions were open ended and asked the teaching assistants to respond to their conceptions of various decisions and situations in the classroom.

Since this instrument is original and was developed by the researcher, validity of the instrument was obtained by a.) pilot testing the questions on 30 teaching assistants in Biology 1008/1009 winter quarter 1992 and b.) having education professionals make refinements and adjustments. The intent behind gaining validity for the instrument was to make certain that the questions measured what they were intended to measure.

Interview Protocol

The teaching assistants were all interviewed three times during the course, after three laboratory lessons they had just taught. The purpose of the interview was to obtain more clear information about how teaching assistants make decisions during lessons to reveal more clearly their conceptions about the nature of teaching. The interview questions were developed prior to the interview. The questions were selected based on whether they pertained to teaching in general, planning, assessment of understanding, and effectiveness of instruction (Clark and Peterson, 1986; Livingston and Borko, 1989). These four categories were used because together they look at the entire decision making process that goes into teaching. The interview questions are in Appendix B.

Analysis and Results

The method of analysis used in this study is termed grounded theory. Grounded theory emphasizes the generation of theory and data in which the theory is grounded (Glaser, 1978). Strauss (1987) says that grounded theory is a detailed grounding by systematically and intensively analyzing data, often sentence by sentence, or phrase by phrase of a field note, interview, or other document. By constant comparison, data

are extensively collected and coded, thus producing a well-constructed theory. The focus of the analysis is not only on collecting or ordering the data, but on organizing many ideas that have emerged from analysis of the data (Strauss, 1987).

The data analysis procedures was focused on the teaching assistants pre and post responses. To obtain answers to the first question, data analysis was focused on the teaching assistants' responses to the Nature of Teaching questionnaire. For the second question, data from teaching assistants' interviews were analyzed. Finally, the data from the Nature of Teaching questionnaire and interviews were compared to answer the third question.

Each response to an item on the Nature of Teaching questionnaire and the interview questions was analyzed according to its relation to subject matter, pedagogical, or pedagogical subject matter knowledge conception of the nature of teaching. The answer to the purposes of the study is presented according to the four categories of teaching as presented on the Nature of Teaching questionnaire and in the interview questions: teaching in general, planning, assessment, and effectiveness of instruction. The entire responses to the questions were broken down into phrases that were coded. Responses to a question were coded as one code. On the Nature of Teaching Questionnaire some questions asked for more than one response, therefore, more those responses were coded as more than one code, for example: What are three characteristics of good teaching? For this item, each response was coded for a total of three responses. The criteria for categorization of the responses to both the Nature of Teaching Questionnaire and the interview questions were:

1. The responses that clearly presented the idea that good teaching had to do with the knowledge of the discipline were categorized as having the subject matter knowledge view of the nature of teaching .
2. The responses that clearly presented the idea that good teaching had to do with the knowledge of classrooms, their management and their organization for the promotion of learning were categorized as having the pedagogical knowledge view of the nature of teaching.
3. The responses that clearly presented the idea that good teaching had to do with using teaching strategies that are specific to the discipline were categorized as having the pedagogical subject matter knowledge view of the nature of teaching.

The categorization of the statements on the Nature of Teaching questionnaire and interview questions as subject matter knowledge, pedagogical knowledge, and pedagogical subject matter knowledge was done by obtaining consensus between the two researchers and one graduate student from science education, who was also involved in the creation of the course and teaching assistants instruction. In order to check for reliability in the coding both intercoder and intracoder reliability measures were obtained. For intercoder reliability, one of the researchers coded the responses and then recoded to calculate a percentage of agreement between the two codes. The intercoder reliability on the Nature of Teaching Questionnaire was 80.4% and for the interview questions was 81.2%. For intracoder reliability, a graduate student with knowledge about the subject matter and pedagogy coded a sample of the responses. The percentages of agreement between the researchers' codes and the graduate students' codes was calculated. The intracoder reliability on the Nature of Teaching Questionnaire was 79.2% and for the interview questions was 80.1%.

The data from pre and post Nature of Teaching questionnaire and interview questions of each item was put together in the form of charts to present the direction of changes in the teaching assistants' conceptions of teaching. Frequencies and percentages of teaching assistants' responses on each question and in each final category were determined, (Table 1: Nature of Teaching Questionnaire; Table 2: Interview Questions), and the number and directions of changes from pretest to posttest were figured (Table 3: Nature of Teaching Questionnaire; Table 4: Interview Questions).

Table 1: Comparison of Pre and Post Conception Changes on the Nature of Teaching Questionnaire

	PRE			POST		
Item	**smk**	**pk**	**psmk**	**smk**	**pk**	**psmk**
Teaching in General (n=76)						
1	(2) 22%	(4) 44%	(3) 33%	(1)10%	(5) 45%	(5) 45%
2	(2) 20%	(5) 50%	(3) 30 %	(0) 0%	(3) 33%	(6) 67%
3	(0) 0%	(10)100%	(0))%	(1)12%	(6) 75%	(1)12%
4	(1)10%	(4) 80%	(1)10%	(1)12%	(4) 50%	(3) 37%
5	(7) 64%	(1) 10%	(3)26%	(4) 36%	(0) 0%	(7) 64%
6	(7) 64%	(1) 10%	(3)26%	(1)10%	(0) 0%	(0)90%
7	(0) 0%	(6)50%	(6)50%	(0) 0%	(7)64%	(4)36%
Totals 19	**22**	**19**	**8**		**25**	**26**
Planning (n=36)						
8	(3)33%	(5)56%	(1)11%	(2)16%	(8)67%	(2)17%
9	(3)30%	(5)50%	(2)20%	(1)10%	(6)50%	(4) 40%
10	(2)22%	(4)44%	(3)33%	(0) 0%	(2)25%	(6)75%
11	(0) 0%	(4)100%	(0) 0%		(0) 0%	(4)67% (2)33%
12	(0) 0%	(0) 0%	(4)100%		(0) 0%	(0) 0% (4)100%
Totals 8	**18**	**10**	**3**		**20**	**18**
Assessment (n=16)						
13	(1)14%	(4)57%	(2)29%	(1)13%	(3)37%	(4)50%
14	(5)62%	(0) 0%	(3)38%	(2)29%	(1)14%	(4)57%
15	(1)12%	(1)12%	(6)76%	(0) 0%	(2)33%	(4)67%
16	(0) 0%	(3) 50%	(3)50%	(0) 0%	(0) 0%	(8)100%
Totals 7	**8**	**14**	**3**		**6**	**20**
Evaluation (n=28)						
17	(0) 0%	(5)40%	(6)60%	(0) 0%	(2) 20%	(6)80%
18	(0) 0%	(5)55%	(4)45%	(0) 0%	(2)22%	(7)78%
19	(0) 0%	(6)100%	(0) 0%		(0) 0%	(3)50% (3) 50%
Totals 0	**16**	**10**	**0**		**8**	**16**

smk = subject matter knowledge
pk = pedagogical knowledge
psmk = pedagogical subject matter knowledge
n = number of total responses

Table 2: Comparison of Pre and Post Conception Changes on the Interview Questions

	pre-experience			post-experience		
Item	**smk**	**pk**	**psmk**	**smk**	**pk**	**psmk**
Teaching in General (n=12)						
1		(4)100%			(2)50%	(2)50%
2	(1)25%	(3)75%			(2)50%	(2)50%
3	(2)50%	(2)50%			(2)50%	(2)50%
Total	**3**	**9**	**0**	**0**	**6**	**6**
Planning (n=4)						
4		(4)100%			(2)50%	(2)50%
Total	**0**	**4**	**0**	**0**	**2**	**2**
Assessment (n=12)						
5		(4)100%				(4)100%
6		(4)100%				(4)100%
7		(4)100%			(1)25%	(3)75%
Total	**0**	**12**	**0**	**0**	**1**	**11**
Evaluation (n=16)						
8		(1)25%	(3)75%			(4)100%
9		(1)25%	(3)75%		(1)25%	(3)75%
10	(1)25%	(3)75%			(3)75%	(1)25%
11		(4)100%				(4)100%
Total	**1**	**9**	**6**	**0**	**4**	**12**

smk = subject matter knowledge
pk = pedagogical knowledge
psmk = pedagogical subject matter knowledge
n = number of total responses

Table 3: Number and Direction of TAs who changed their Conceptions on the Nature of Teaching Questionnaire

Item	smk-pk	smk-psmk	pk-smk	pk-psmk	psmk-pk	psmk-smk
Teaching in General						
1		1(25%)		2(50%)		
2		2(25%)		1(25%)		
3			1(25%)	1 (25%)		
4		1(25%)	1(25%)	1 (25%)		
5		1(25%)		1 (25%)		
6		3(75%)		1 (25%)		
7				1(25%)	1(25%)	
Planning						
8	2(50%)	1(25%)		1(25%)	1(25%)	
9	2(50%)	2(50%)			1(25%)	
10	1(25%)	1(25%)		1(25%)		
11				2(50%)		
12						
Assessment						
13		1(25%)		3(75%)		
14	2(50%)	1(25%)				
15	1(25%)			1(25%)	1(25%)	
16				2(50%)		
Evaluation						
17				2(50%)		
18				2(50%)		
19				3(75%)		

smk = subject matter knowledge
pk = pedagogical knowledge
psmk = pedagogical subject matter knowledge

TABLE 4-4: Number and Direction of TAs who changed their Conceptions on the Interview Questions

Item	smk-pk	smk-psmk	pk-smk	pk-psmk	psmk-smk	psmk-pk
Teaching in General:						
1				2 (50%)		
2	1 (25%)			2 (50%)		
3		2 (50%)				
Planning:						
4				2 (50%)		
Assessment:						
5				4 (100%)		
6				4 (100%)		
7				3 (75%)		
Evaluation:						
8				1 (25%)		
9						
10	1 (25%)			1 (25%)		
11				4 (100%)		

smk = subject matter knowledge
pk = pedagogical knowledge
psmk = pedagogical subject matter knowledge

Summary and Discussion

Nature of Teaching Questionnaire

Teaching assistants' conceptions of the nature of teaching as measured by the nature of teaching questionnaire changed substantially after participating in the instruction program and teaching throughout the quarter. Most of the teaching assistants changed their conceptions to pedagogical subject matter knowledge on teaching in general (item's #2,5,6), planning (item #10), assessment (item's # 13, 16), and evaluation (item's # 17,18,19).

In assessing each category as a whole instead of item by item, changes are revealed in each category. In category one, Teaching in General, there was a

substantial decrease in the total number of responses from pre to post in choosing subject matter knowledge. There was no comparable change pre to post in choosing pedagogical knowledge. Consequently, there was a modest increase in the total number of responses from pre to post in choosing pedagogical subject matter knowledge.

In the second category, Planning, there was a modest decrease in the total number of responses form pre to post in choosing subject matter knowledge. There was no comparable change pre to post in choosing pedagogical knowledge. Consequently, there was a substantial increase in the total number of responses from pre to post in choosing pedagogical subject matter knowledge.

In the third category, Assessment, there was a modest decrease in t he total number of responses form pre to post in choosing subject matter knowledge. There was no comparable change pre to post in choosing pedagogical knowledge. Consequently, there was a modest increase in the total number of responses from pre to post in choosing pedagogical subject matter knowledge.

In the final category, Evaluation, there was no comparable change pre to post in choosing subject matter knowledge. There was a substantial decrease in the total number of responses from pre to post in choosing pedagogical knowledge. Consequently, there was a substantial increase in the total number of responses form pre to post in choosing pedagogical subject matter knowledge.

Interview Questions

Teaching assistants' conceptions of the nature of teaching as measured by the interviews changed substantially after participating in the instruction program and teaching throughout the quarter. Most of the teaching assistants changed their conceptions to pedagogical subject matter knowledge on assessment (items # 5,6,7), evaluation (item #11). The teaching assistants stayed consistent with their pedagogical subject matter knowledge conceptions on evaluation (items #8,9).

In assessing each category as a whole instead of item by item, changes are revealed in each category. In category one, Teaching in General, there was a modest decrease in total number of responses pre to post in choosing subject matter knowledge. There was a modest decrease in total number of response pre to post in choosing pedagogical knowledge. Consequently, there was a substantial increase in total number of responses pre to post in choosing pedagogical subject matter knowledge.

In the second category, Planning, there was no comparable change pre to post in choosing subject matter knowledge. There was a modest decrease in total number of responses pre to post in choosing pedagogical knowledge. There was a modest increase in total number of responses pre to post in choosing pedagogical subject matter knowledge.

In the third category, Assessment, there was no comparable change pre to post in choosing subject matter knowledge. There was a substantial decrease in total number of response pre to post in choosing pedagogical knowledge. There was a substantial increase in total number of responses pre to post in choosing pedagogical subject matter knowledge.

In the final category, Evaluation, there was no comparable change pre to post in choosing subject matter knowledge. There was a substantial decrease in total number of responses pre to post in choosing pedagogical knowledge. There was a substantial increase in total number of responses pre to post in choosing pedagogical subject matter knowledge.

According to the results from this study, teaching assistants did change their overall conceptions about the nature of teaching in each category. Teaching assistants conceptions of the nature of teaching seemed to change as a result of instruction and teaching experience. this may indicate that teaching assistants have not formed concrete conceptions of teaching that are resistant to change or influence. Therefore, it may be imperative to expose teaching assistants to direct instruction on pedagogy with subject matter early on in their experience as teachers in order to help build their conceptions of teaching.

Comparison of the Nature of Teaching Questionnaire and Interview Responses

To analyze data for this question, teachers' responses to the Nature of Teaching questionnaire and their comments about the nature of teaching in the interview were compared. The comments from pre-experience interview responses were compared to the related pretest responses of the Nature of Teaching questionnaire and the comments from post experience interview responses were compared to the related posttest responses of the Nature of Teaching questionnaire.

The overall relationship between teaching assistants' perceptions about the nature of teaching measured by the Nature of Teaching questionnaire and their comments in the interviews were compared by showing relationships in the changes made on the instruments pre and post.

Since each measure asked different questions, it was hard to show a question by question analysis. But what was discovered after analysis of the two sources, on the post evaluation, is that there was a tendency for the teaching assistants to changed in their conceptions on the assessment of student understanding and evaluation of effective instruction toward using a the pedagogical subject matter knowledge approach. What follows is an analysis of the two measures and how they compare.

In the questionnaire, their was a substantial change to the use of pedagogical subject matter knowledge in questions #2, the reasons for the characteristics of good teaching, #5 the important things to teach in introductory biology, #6 the reasons behind the important things to teach in introductory biology, #10 how to determine what is important to teach, #13 how to assess whether or not a student understands, #16 the best ways for students to learn biology, #17 the elements of effective instruction, #18 the reasons behind the elements of effective instruction, and #19 how to evaluate the effectiveness of instruction.

In the interview, there was a change to the use of pedagogical subject matter knowledge in items # 5 assessment of student understanding, #6 how to correct student misunderstandings, #7 feeling comfortable with students not understanding, #11 making decisions in the classroom. Also apparent in the interview questions is that teaching assistants maintained consistent reference to pedagogical subject matter knowledge in items# 8 evaluate the effectiveness of instruction, and #9 why students have trouble with this lab.

In summary, there was a consistent relationship between the two measures of the teaching assistants' conceptions of the nature of teaching in the areas of assessment and evaluation on the post evaluation. Assessment being items # 13,16 on the questionnaire, # 5,6,7 on the interview and Evaluation being items # 17,18,19 on the questionnaire, # 8,9,11 on the interview.

Implications and Recommendations

This study presented evidence that teaching assistants conceptions of the nature of teaching can be changed. The implication from the findings in this study imply that teaching assistants conceptions can be influenced and changed if the teaching assistants are challenged about their conceptions of teaching.

The challenge to the teaching assistants, in this study, came from directly relating pedagogy to the subject matter in the instruction they received before they taught the laboratories. This approach to instruction was influenced by a number of

theorists that support the principle that teaching strategies should match the discipline. This study supported the claim that it is valuable to directly relate pedagogy to subject matter in instruction by showing evidence that the teaching assistants did change their conceptions of teaching.

It is reasonable to assert, from the findings in this study, that instruction that combines pedagogy directly with subject matter can be effective in changing and influencing teachers conceptions of the nature of teaching. Therefore, one way to enhance growth in teaching assistants conceptions of teaching, it is recommended that instruction on pedagogy be conducted that is directly related to the subject matter.

It is important that we understand teaching assistants' conceptions of teaching to provide instruction that successfully prepares teaching assistants to teach at the college level. Furthermore, it is imperative that we start to recognize the impact that graduate training and college teaching has on the preparation of our K-12 teachers. Our future K-12 teachers are significantly influenced by college teachers, therefore, it is imperative that current practices in college classrooms be examined.

The intent of this study is not to suggest that all educational instruction for teaching assistants and future teachers be discipline specific. It is recognized that there are teaching practices that are generic across disciplines, however, evidence from this study suggests that instruction on pedagogy directly related to subject matter challenges teachers' conceptions of teaching and prepares them to recognize how to more effectively combine their teaching practices with their subject matter.

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APPENDIX A

Table 3-1: Nature of Teaching Questionnaire

Teaching in General:

1. What are three characteristics of good teaching? (style)
2. For each of the three characteristics above, explain why you think it is important?
3. What are three characteristics of a good teacher? (personal attributes)
4. For each of the three characteristics above, explain why you think it is important?
5. What are the three important things to teach in an introductory biology course?
6. For each of the above things you think should be taught, explain why you think it is important?
7. Once you have mastered the content of your field, what more do you need to know to be a successful teacher?

Planning:

8. Describe three techniques you use to plan for a lesson?
9. for each of the above techniques, explain why you think it is important?
10. How do you determine what is important to teach?
11. At the beginning of the course, what information about students and how they learn is important to you?
12. What is the best way to teach science and why?

Assessment:

13. How do you assess whether or not a student understands?
14. What do you think are the most common reasons students have trouble understanding biological concepts?
15. For each of the above reasons, what would you do to help students understand?
16. What are the best ways for student to learn biology?

Effectiveness of Instruction:

17. What are three elements of effective instruction?
18. For each of the above elements of instruction, explain why you think it is important?
19. How do you evaluate the effectiveness of your instruction?

Appendix B

Interview Questions

1. How do you feel about the lab in general?
2. What went best in the lab? What went worst in the lab?
3. What did you like the most and worst in the lab?
4. Do you think there is anything you would change in your planning for this lab?
5. How did you assess student understanding?
6. How did you correct student misunderstanding?
7. Did you feel comfortable with students not understanding?
8. How would you evaluate the effectiveness of your instruction? What do you use as measures of success in your instruction?
9. Why do you think students would have trouble with this lab, or do you think they had any trouble?
10. If there was anything you would change about this lab or your instruction what would it be?
11. How do you make decisions in the classroom?

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